

The copper/zinc cell (Daniell cell) - Leerlaufspannung eines galvanischen Elements with Cobra SMARTsense



With the help of this experiment, the students learn about one of the most classic galvanic elements, the Daniell element.

Chemistry	Physical chemistry	Electrochemistry	Electrochemical measurement set
Chemistry	Physical chemistry	Electrochemistry	Galvanic elements, fuel cells
 Difficulty level medium	 Group size 2	 Preparation time 10 minutes	 Execution time 20 minutes

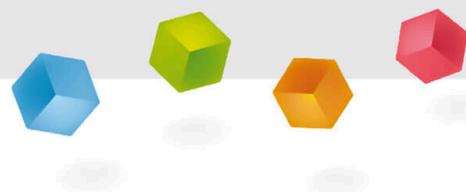
This content can also be found online at:



<https://www.curriculab.de/c/68a83d99a65c99000273a79d>

PHYWE

Teacher information



Application

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Two electrodes in salt solutions form the simplest form of a battery. They serve as an electrical source and generate a voltage.

The discovery of the **galvanic elements** - better known as **batteries** - enable the mobile power supply of many devices and characterise our everyday lives. They serve as a source of electrical energy and supply voltage.

A well-known example is the **Daniell element**: It consists of a zinc and a copper half-cell. It is often used as a simple model for galvanic cells in the classroom.

Other teacher information (1/8)

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Prior knowledge



The students should already know what a galvanic cell is and how it is constructed.

Principle



In a complete "galvanic cell" (also known as a galvanic element), two different metal electrodes are each immersed in aqueous solutions of one of their own salts. Electrons flow across a salt bridge (current key) between the cells, creating a voltage difference.

Other teacher information (2/8)

PHYWE

Learning objective



Students learn about the Daniell element, a classic example of a galvanic cell. The terms **Electrical potential** and **Potential difference** introduced. They also learn that the measured voltage under standard conditions corresponds to the open-circuit voltage of the cell and which factors influence these conditions.

Tasks



The students build two galvanic elements $\text{Zn}|\text{Zn}^{2+}||\text{Cu}^{2+}|\text{Cu}$ with different salt concentrations and compare their tensions. In the experiment, they investigate the function of the individual components of both cells.

Other teacher information (3/8)

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In this experiment, a complete **galvanic cell** (also **galvanic element** called) can be built up. The terms potential and potential difference can be introduced.

A galvanic cell consists of two different metal electrodes, each of which is immersed in an aqueous solution of one of its own salts. In a copper-zinc cell, the **Copper electrode** in copper sulphate solution, which **Zinc electrode** in zinc sulphate solution.

For the current flow between the two solutions, a **Power key** A conductive compound is required to enable the flow of ions. For example, chromatography or filter paper soaked in potassium nitrate solution can be used, one end of which is immersed in each of the two solutions.

The system consisting of a metal electrode and the corresponding salt solution is called a **Half cell** or **Half element** is labelled. A complete galvanic cell therefore consists of two half cells, two electrodes and the connecting current key.

Other teacher information (4/8)

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The dissolution pressure of a metal is its endeavour to dissolve in contact with water and is given as a concentration. The strength of this endeavour is referred to as the dissolution pressure or electrical potential.

As each metal has its own solution pressure, the oxidation reactions in the half-cells take place at different rates. If two such half-cells are connected, a potential difference is created, i.e. an electrical voltage. The magnitude of this voltage results from the difference between the standard potentials E° of the two metals.

These standard potentials define how "base" or "noble" a metal is. Zinc ($E^\circ = -0,76 \text{ V}$) is less noble than copper ($E^\circ = 0,34 \text{ V}$).

Other teacher information (5/8)

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The following applies to the zinc-copper element:



If the reactions at the electrodes are viewed as equilibria, the equilibrium for zinc oxidation is further to the product side than for the copper reaction. As a result, more electrons accumulate on the zinc electrode than on the copper electrode. The zinc electrode therefore becomes the negative pole, the copper electrode the positive pole.

If both electrodes are connected (e.g. with a cable), the electrons flow from the zinc to the copper. The galvanic element now functions as a current source. The states at the electrodes change: Zinc atoms increasingly go into solution at the zinc electrode, while copper ions are deposited as copper at the copper electrode by absorbing electrons. Electrolyte anions and sulphate ions can diffuse through the salt bridge to the zinc half-cell to enable charge equalisation.

Other teacher information (6/8)

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The oxidation of zinc and reduction of copper ions to solid copper can be observed directly in an additional experiment. If the zinc electrode is briefly immersed in copper sulphate solution, finely dispersed copper is immediately deposited. A grey-black layer forms on the zinc, which cannot be rinsed off with water.

The following has been defined for naming the electrodes in electrochemical cells:

Anode: Oxidation - Electrons are emitted (zinc half-cell, negative pole).

Cathode: Reduction - Electrons are absorbed (copper half-cell, positive pole).

In the copper-zinc cell, the zinc electrode (negative pole) is the anode and the copper electrode (positive pole) is the cathode.

Other teacher information (7/8)

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The difference between the potentials of two half cells results in the **Open circuit voltage**. If the measurement is performed under **Standard conditions** (temperature: 25° C concentration: 1 mol/L, Print: 1, 013 bar), it corresponds to the difference between the **Standard potentials**:

$$\Delta E = E_{\text{Kathode}} - E_{\text{Anode}}$$

The voltage in the open circuit is called **Open circuit voltage** the voltage in the closed circuit is the **Clamping voltage**. The open-circuit voltage is always slightly higher than the clamping voltage.

When measuring with a high-impedance voltmeter such as the Cobra SMARTsense Voltage (internal resistance in the megaohm range) and a low internal resistance of the galvanic element, the following applies: clamping voltage \simeq Open-circuit voltage.

Other teacher information (8/8)

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The solutions can be produced for everyone to save chemicals!

- **Copper sulphate solution (1 mol/l):** Add 124, 85 g Copper sulphate to 250 ml distilled water. Mix well and fill up to 500 ml with distilled water.
- **Zinc sulphate solution (1 mol/l):** Add 143, 77 g Zinc sulphate to 250 ml distilled water. Mix well and fill up to 500 ml with distilled water.
- **Potassium nitrate (1 mol/l):** Add 50, 5 g Potassium nitrate to 250 ml distilled water. Mix well and fill up to 500 ml with distilled water.
- **Copper and zinc sulphate solution (0, 1 mol/l):** Take each 2 ml of the 1M solutions and pour them into two beakers. Then add 18 ml of distilled water. Mix well!

When using this approach variable, a 600 ml beaker can be used. You can find this in the PHYWE webshop.

Safety instructions

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- The general instructions for safe experimentation in science lessons apply to this experiment.
- All persons in the room must wear safety goggles during the experiment!
- Zinc sulphate solutions of the concentration $c = 1,0 \text{ mol/l}$ have an irritant effect.
- For H and P phrases, please refer to the safety data sheet of the respective chemical.

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Student information



Motivation

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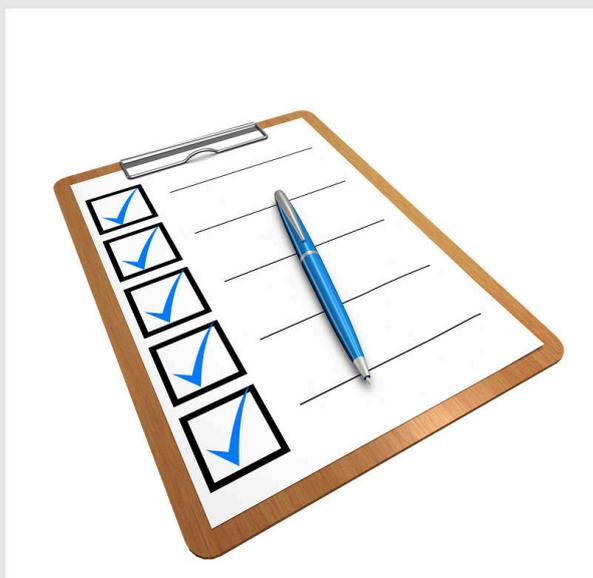


Batteries have become an integral part of everyday life - they supply many devices with power and are therefore indispensable for the operation of a drone. The basis for this are batteries, the functioning of which is based on **galvanic elements** which convert chemical energy into electrical energy.

In this experiment, you will learn about one of the best-known galvanic elements: the **Daniell element** (copper/zinc cell). You will learn how electrical energy can be generated with the help of two metals and their salt solutions.

Tasks

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How does a battery actually work?

1. Set up two galvanic cells with copper and zinc electrodes that differ only in the concentration of the salt solutions.
2. Investigate the tasks of the individual components of the galvanic cell (electrodes, salt solutions, current dish)
3. Measure and compare the voltages of the two cells. How does the concentration of the salt solutions affect the voltage?

Equipment

Position	Material	Item No.	Quantity
1	Cobra SMARTsense Voltage - Sensor for measuring electrical voltage ± 30 V (Bluetooth + USB)	12901-01	1
2	Connecting cord, 2 mm-plug, 5A, 500 mm, red	07356-01	1
3	Connecting cord, 2 mm-plug, 5A, 500 mm, blue	07356-04	1
4	Reducing plug 4mm/2mm socket, 2	11620-27	2
5	Alligator clip, insulated, 2 mm socket, 2 pcs.	07275-00	2
6	Copper strip electrode for student electrochemistry experiments Length: 75 mm, width 15 mm	07856-10	1
7	Block with 8 holes, d = 40 mm	37682-00	1
8	Coverage f.cell-meas.bloc,8 piec.	37683-00	1
9	Beaker, Borosilicate, tall form, 50 ml	46025-00	4
10	Dropping bottle,plastic,50ml	33920-00	1
11	Zinc strip electrode for student electrochemistry experiments Length: 75 mm, width 15 mm	07856-20	1
12	Beaker, Borosilicate, tall form, 50 ml	46025-00	4
13	Copper-II sulphate,cryst. 250 g	30126-25	1
14	Zinc sulphate 7-hydr. 250 g	30249-25	1
15	Potassium nitrate 250 g	30106-25	1
16	Water, demineralized, pure, 10000 ml	CHE-882041145	1
17	Chromatographic paper 100 stripes	32972-00	1
18	Protecting glasses, clear glass	39316-00	1

Additional material

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Position	Equipment	Article no.	Quantity
1	Tweezers	64610-01	1

Setup (1/5)

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For measurement with the **Cobra SMARTsense sensors** the **PHYWE measureAPP** required. The app can be downloaded free of charge from the relevant app store (see below for QR codes). Before starting the app, please check whether your device (smartphone, tablet, desktop PC) is running **Bluetooth activated** is.



iOS



Android



Windows

Setup (2/5)

PHYWE

The solutions can be produced for everyone to save chemicals!

- **Copper sulphate solution** (1 mol/l): Add 12,5 g Copper sulphate to 25 ml distilled water. Mix well and fill up to 50 ml with distilled water.
- **Zinc sulphate solution** (1 mol/l): Add 14,4 g Zinc sulphate to 25 ml distilled water. Mix well and fill up to 50 ml with distilled water.
- **Potassium nitrate** (1 mol/l): Add 5,1 g Potassium nitrate to 25 ml distilled water. Mix well and fill up to 50 ml with distilled water.
- **Copper and zinc sulphate solution** (0,1 mol/l): Take each 2 ml of the 1M solutions and pour them into two beakers. Then add 18 ml of distilled water. Mix well!

Setup (3/5)

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Moisten two salt bridges one after the other in the potassium nitrate solution using tweezers and place them as a bridge between two measuring cells in the measuring cell block (see figure).



Setup (4/5)

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Fill the salt solutions into the corresponding measuring cells of the measuring cell block as shown in the illustration.

Place a measuring cell cover on each measuring cell.



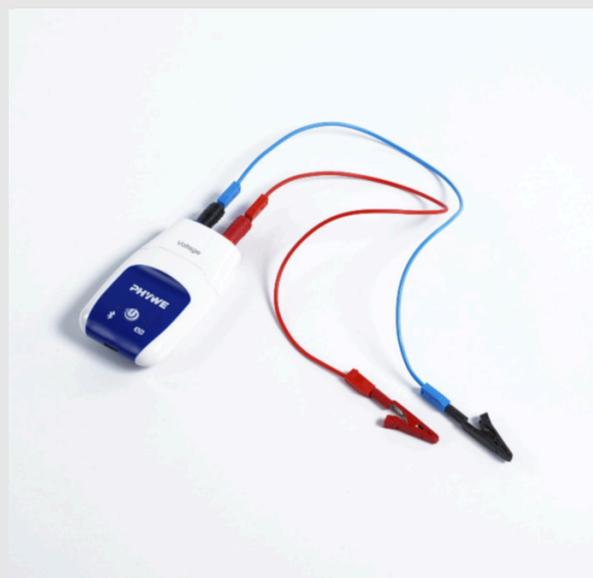
Setup (5/5)

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Look at the two electrodes, copper (Cu) and zinc (Zn): If the metal has oxidised due to storage, use a piece of sandpaper to remove the oxide layer.

Note the colour of the connections below: blue (zinc, negative pole) always to blue (black) and red (copper, positive pole) always to red!

Connect the crocodile clips to the metal electrodes (copper and zinc sheet) and the leads to the Cobra SMARTsense Voltage Sensor using a reducing plug.



Procedure (1/2)

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- Start the measureAPP on a mobile device.
- Press the start button on the sensor for approx. 3 seconds.
- Connect the sensor by tapping  next to the description of the sensor in the measureAPP.
- Set the measured value display by tapping **0.0** above the diagram.



Devices

- Apple iPad13,16 - Accelerometer (internal)  
-  4885 - Voltage

Measurement channel 

Configuration 

 4885 - Voltage  

Measurement channel 

Voltage

 U [V]  

Calculated channels 

U 0,00 V

Procedure (2/2)

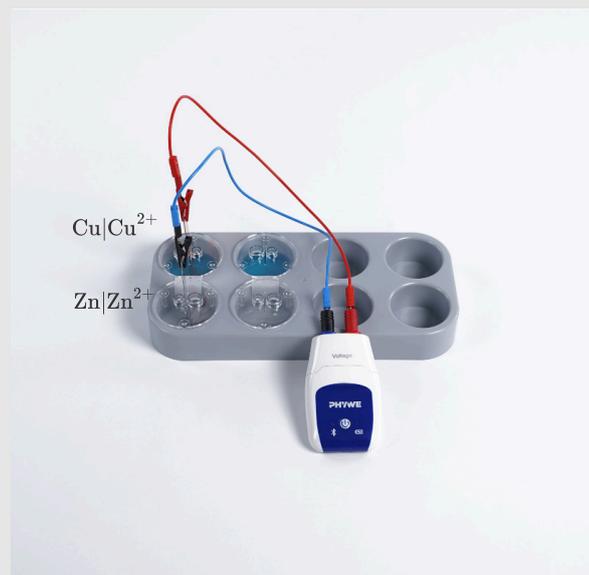
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Make sure that the electrodes do not touch each other during the measurement!

First insert a copper electrode into the diluted copper sulphate solution (measuring cell 1) and a zinc electrode into the diluted zinc sulphate solution (measuring cell 2).

Observe the voltage displayed in the measureAPP and note it down as soon as it reaches a constant value.

Then rinse the electrodes with distilled water and clean the surface of at least the copper electrode with emery paper. Carry out the same measurement in the concentrated salt solutions.



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Report

Task 1

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How does the Daniell element work? Drag the words into the correct fields!

In the Daniell element, the oxidation of Zn to Two are released in the process. The electrons move to the cathode, where the of to Cu takes place.

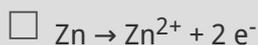
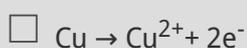
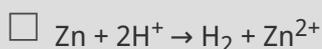
The of the Daniell element is 1,1 V.

 Check

Task 2

PHYWE

Metals are known to endeavour to change to the dissolved state in aqueous solutions. Select the solution equations of copper and zinc.

 There can be no solution equation for copper and zinc, as both are semimetals. Check

Task 3

PHYWE

What is the function of the salt bridge in a galvanic cell?

 It enables ion exchange. It physically separates the electrodes. It increases the tension. It conducts the electrons. Check

Task 4

PHYWE

Which statements apply?

- The standard potential describes the conductivity of the electrode.
- The potential is calculated between the two half cells: $\Delta E = E_{\text{Kathode}} - E_{\text{Anode}}$.
- If measurements are carried out under standard conditions, the open-circuit voltage corresponds to the difference between the standard potentials.
- The potential of two half cells in an open circuit is referred to as the open-circuit voltage.

✓ Check

Task 5

PHYWE

Calculate the standard potential (the open-circuit voltage) of the Daniell element. The half-cell reactions are given:



- The standard potential or open-circuit voltage is $-1,1 \text{ V}$.
- The standard potential or open-circuit voltage is $1,1 \text{ V}$.
- The standard potential or open-circuit voltage is $0,76 \text{ V}$.

✓ Check

Task 6

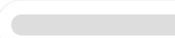
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What conditions must be met for the measured voltage of a galvanic cell to correspond to the standard open-circuit voltage?

- No current may flow.
- The ion concentration must 1 mol/L amount.
- The metal salt solutions of the half cells must have different concentrations.
- A load must be connected.

✓ Check

Slide	Score/Total
Slide 25: How does the Daniell element work?	0/5
Slide 26: Solution equation	0/2
Slide 27: Salt bridge	0/1
Slide 28: Summary: Daniell element	0/3
Slide 29: Standard potential or open-circuit voltage of a galvanic ...	0/1
Slide 30: Untitled: Multiple Choice	0/2

Total amount  0/14

👁 Solutions

🔄 Repeat